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Effect of *Talaromyces pinophilus* and SP36 on Phosphate Available and Potato (*Solanum tuberosum* L) Production on Andisol Impacted by Mount Sinabung Eruption, North Sumatera, Indonesia.

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Abstract

Mount Sinabung erupted in September 2013, the volcanic ash is falling volcanic material ejected into the air during an eruption. Andisol formed from volcanic ash, which is rich in minerals Al and Fe which can bind phosphates making it unavailable to plants. In vitro screening of fungal from surrounding horticulture land, on their ability to dissolve phosphate showed that *Talaromyces pinophilus* was the best fungal. The aim of this study was to examine the capability of *T. pinophilus* and P fertilizer on Andisol in improving soil P- available and production of potato (*Solanum tuberosum* L). The research design used was factorial randomized block with two factors. Factor I was the volume of *T. pinophilus* inoculum, consist of 3 treatments; without *T. pinophilus* 10 mL, 20 and 30 mL *T. pinophilus* inoculum. Factor II was the dosage of SP36, consist of 3 treatments: 50%, 75%, and 100% from recommended dosage (6.5 g, 9.75 g and 13 g SP36/plant respectively). The control treatment was potato plant without applying *T. pinophilus* but adding 7.8 g Urea, 10 g KCl and 13 g SP36 (100% suggested P fertilizer) which was applied twice with the same dosage.

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The results showed that application of *T.pinophilus* application and P fertilizer dosage increased shoot dry weight 8.8-72.23%, soil P available 14.78-64.79%, P-uptake 8.75-53.95% and tuber yield 1.43-66.72% compared with control. The best treatment in increasing potato tuber yield was 20 ml *T.pinophilus*/plant and 6.5 g SP36/plant.

Keywords: Andisol; *Talaromyces pinophilus*; potato(*Solanum tuberosum* L); SP36.

1. Introduction

Phosphorus (P) is an important mineral macronutrient required for proper growth and development of plants [2]. However, a greater part of soil P, approximately 95–99 %, is insoluble and, hence, cannot be utilized by the plants. The rapid fixation of P by soil constituents leads to soil P deficiency [13]. The main source of P is rock, which is not renewable, making this resource limited. P is derived from the parent materials which are mostly insoluble, except in certain circumstances.

Andisol is one of the soil types that has problem with the availability of phosphate [10] Karo plateau is a horticulture center in North Sumatra, and the soil in this area is Andisol. It has volcanic ash and rich of minerals and contains Al and Fe in huge amount. The retention of P in Andisol soil in Kutarayay village, Karo plateau, or north of Mount Sinabung ranged from 95.04-99.44% [7]. According to Balitbangtan [1] the volcanic ash materials of Mount Sinabung contained such elements as S (0.05-0.32%) Fe (0.58-3.1%), and Pb (1.5-5.3%). Meanwhile, Cd, As, Ag and Ni were undetectable. The soil pH was 4.4-6.5 and the volcanic ash pH was 3.3-3.5, with pH thereby causing the availability of P to be low.

Plants can only absorb P in the available forms. However, the efficiency of P fertilizers is still low and range between 5 and 10% [4]. The P of land becomes available through the secretion of organic acids produce by roots or microbes. In this regard, P supply through biological systems is considered a viable alternative, and inoculation of P-solubilizing microorganisms, especially fungi to soil, is a reliable source for increasing soluble P in soil. Phosphate-solubilizing fungi have been reported from different ecological. Following inoculation, phospho-fungi have proved to improve the growth of horticultural crop [9]. Fungal species like *Talaromyces* and *Eupenicillium* are considered “key organisms” in the P cycle [14]

In Karo highland, potato (*Solanum tuberosum* L.) is one of the horticultural crops and needs P in huge amount. In providing P nutrient for plants, the fungi of phosphate solvent were never taken into account. Therefore, the objective of this study was to measure the potential of the bacteria of phosphate solvent *T.pinophilus* at various doses of SP36 fertilizer in improving the availability and production of potato crops in the Andisol soil impacted by the eruption of Mount Sinabung.

2. Materials and Methods

The research was conducted in Kutarayay Village, Naman Teran District, Karo Regency (North of Mount Sinabung) in July 2014 – December 2014, and the following characteristics: pH H₂O 4.29, C 5.74%, N 0.56%, P total 2538.76 mg/kg, P available 81.49 mg/kg, 0.4%K, and CEC 46.29 me/kg.

The materials used in this study were *Talaromyces pinophilus* isolates, which were isolated from the rhizosphere of the potato plants affected by the eruption of Sinabung, and had been tested for their ability to dissolve phosphate. Potato seed of Granola variety, Urea, SP36, KCl, pesticides, insecticides and other materials deemed necessary in this study.

2.1. Experimental Design

This study used Factorial Randomized Block Design with two factors and 3 replications. Factor I was *T.pinophilus* volume, consisting of treatments T1 = 10 mL, T2 = 20 mL and T3 = 30 mL of *T.pinophilus* liquid inoculum/plant. Factor II was SP36 fertilizer dosage, consisting of treatments P1 = 50% of recommended dosage of P fertilizer (6.5 g/plant), P2 = 75% of recommended dose of P fertilizer (9.75 g/plant), and P3 = 100% of recommended dosage of P fertilizer (13 g/plant). The control plant was the potato without the application of *T.pinophilus* but add 7.8 g Urea, 10 g KCl and 13 g SP36 (100% recommended P fertilizer) applied twice with the same dosage. Each treatment have 3 plots, and each plot have 5 plants.

Size of plot was 0.6 x 2.20 m, the distance between plots in the block was 30 cm, and the distance between blocks was 50 cm.

The base fertilizers applied were 7.8 g urea, 10 g KCl, P fertilizer application in accordance with the treatment dosage given one week after the plants grow. Plants were sprayed with insecticide with active ingredient carbosulfan 3 mL/L and fungicide with active ingredient of Mankozebe 2 g/L and picked weeds to prevent their growth.

Inoculation of *T.pinophilus* with population 18×10^9 cfu /mL spreaded around potato roots 1 week after potato planted in the field. Soil and plant samples were taken at the age of plant 50 days after planting. For production parameter, samples were taken 3 months after planting (according to the criteria of the potato crop harvest).

2.2. Analysis of Soil and Plant

The parameters measured were plant wet weight measured at the end of the vegetative period, shoot dry weight measured at the end of the vegetative period, soil pH, available soil P by Bray II method, which was measured at the end of the vegetative period, plant P uptake, which was measured at the end of vegetative period and potato tuber yield.

Statistical Analysis

To determine the significant differences among the treatments, data was analyzed Anova and LSD $\alpha = 0.05$.

3. Results and Discussion

The statistic analysis showed that application of *T.pinophilus* affected P availability and shoot dry weight significantly. Application of P fertilizer significant effected on P shoot dry weight (Table)

Table: The mean of pH, available P, shoot dry weight, plant P uptake and tuber yield of *Talaromyces pinophilus* application and dose of P Fertilizer

Treatment	pH Soil	P availability (ppm)	Shoot dry weight (g)	Plant P uptake (ppm)	Potato tuber weight (g/plant)
<i>T.pinophilus</i> application					
10	4.73	125.01 c	20.85bc	3.65	786.11
20	4.29	91.50 a	17.25a	4.25	611.94
30	4.43	105.08 b	20.78b	4.45	590.71
F	NS	*	*	NS	NS
LSD	-	15.25	2.47	-	-
Fertilizer SP36					
6.5	4.27	95.07	18.36a	3.65	800.14
9.75	4.74	114.31	19.68ab	4.26	514.17
13	4.45	112.21	20.84bc	4.44	683.41
F	NS	*	*	NS	NS
LSD	-	-	2.22	-	-
CV%	5	24.4	12.58	25.47	23.6

Note: Figures in rows and columns followed by lower case letters indicate a significant effect on the level of 5% according to LSD

The P available of *T.pinophilus* application showed that application of *T.pinophilus* increased P available higher compare to control (83.46 ppm). Whereas application of *T.pinophilus* 10 mL, caused P available (125.01 ppm) or 49.78% higher than control. The use of microorganisms capable of mobilizing P into available/soluble forms as biofertilizers is feasible, particularly in sustainable agriculture production systems [8]. P uptake increased with application *T.pinophilus*. The best treatment was 30 mL improved by 5.28% compare to control. Shoot dry weight of treatment 10 mL *T.pinophilus* inoculum/plant was higher compare to other treatments. It was 58.19% higher compare to control. This indicated that application of *T.pinophilus* increased potato growth. Following inoculation, phospho-fungi have proved to improve the growth of horticultural crop [9]. Tuber yield of treatment *T.pinophilus* 10 mL was higher compare to other treatments, increased tuber yield plants 28.87% higher when comparing to control [3] found that the *Bacillus polymyxa* inoculation on potato seed tuber treatment increased potato yield by 52%. Mechanisms of P dissolution are by realising organic acids and chelate Al, Fe, Ca and Mg cause P available for uptaking by plant [12].

Application 9.75 g SP36 increased P available higher compare to control (36.96%). Shoot dry weight with application 13 g SP 36/plant had the highest weight when compared with other treatments, and the weight increased (58.12%) higher compare to control. The best plant P uptake was at treatment 13 g SP 36/plant. Potato tuber weight of treatment 6.5 g SP36 / plant was the highest production when compare to other treatments. The

increased in crop tuber yield was 31.17% higher when compare with a control [6] found that application SP36 improved potato tuber weight up to 721 g/plant. Most P is closely related to starch, especially in cereal grains, and the starch in potato tubers was no exception.

Interaction of *T.pinophilus* treatment and P fertilizer dosage increased P available on treatment 10 ml *T.pinophilus* and 9.75 g SP36 (64.79%) compare to control. Meanwhile, shoot dry weight, the best treatment to increase was 30 mL *T.pinophilus* and 9.75 g SP36 (72.23%) compare to control. The best potato tuber yield (1017.5g/plant) was on treatment 20 mL *T.pinophilus* and 6.5 g SP36 mean while control' tuber yield only 610 g/plant. It was 66.72% higher compare to the control. The experiment conducted by Malboobi et al [5] found that Of all the three PSB, *P. agglomerans* significantly increased the growth and yield of potato plants by about 20–25%.

Interaction of *T.pinophilus* and the dosage of SP36 fertilizer on shoot dry weight in the treatment application of 30 mL *T.pinophilus* and 9.75 g SP36 fertilizer had the highest dry weight. The shoot dry weight of potato decreased with increasng SP36 fertilizer dosage for all *T.pinophilus* inoculum volume (Figure 1). The plant P uptake on treatment of 30 mL *T.pinophilus* and 9.75 g SP36 was the highest compane to other (5.45g), and it decreased with increasing dosage of SP36 except for treatmene 10 mL *T.pinophilus* (Figure 2). Treatment 20 mL *T.pinophilus* and 6.5 g SP36 produced the highest tuber yield (1017.5 g/plant), and it also decreased with increasing dosage SP36 except for treatment 30 mL *T.pinophilus* (Figure 3).

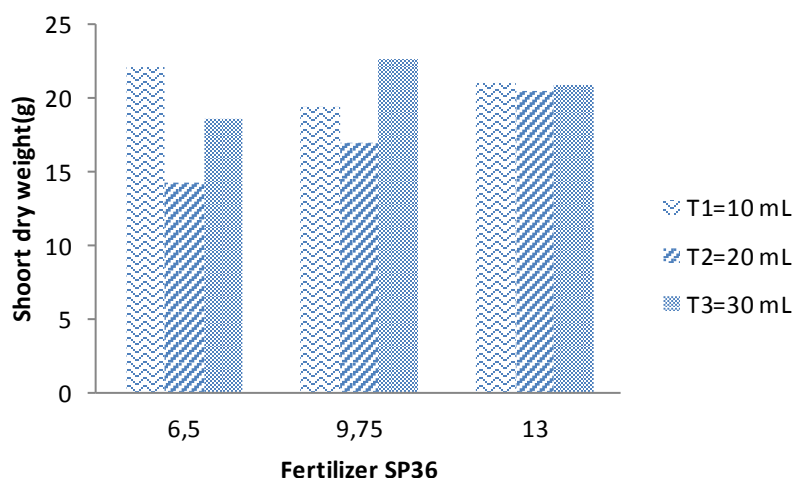


Figure 1:The relationship between *T.pinophilus* and SP36 Fertilizer on Shoot Dry Weight (g)

4. Conclusion

1. Application of *T.pinophilus* increased shoot dry weight (30.88-58.19%), P available (9.63-49.78%), plant P uptake 3.01-28.87%, potato tuber yield 0.3-28.87% compare to control.
2. Application of P fertilizer increased plant growth (39.3-58.18%), P available (13.91-36.96%), plant P uptake (3.01-25.42%) and potato tuber yield (12.03-31.17%) compare the control.

3. Applications of *T.pinophilus* and SP36 increased shoot dry weight (8.8-72.23%), P available (14.78-64.79%), plant P uptake (8.75-53.95%) and potato tuber yield (1.43-66.72%) when compare with control. Therefore, the best treatment was 20 mL *T.pinophilus* / plant and 6.5 g SP36 / plant. Increasing dosage of SP36 will decreasing tuber yield on *T.pinophilus* potato.

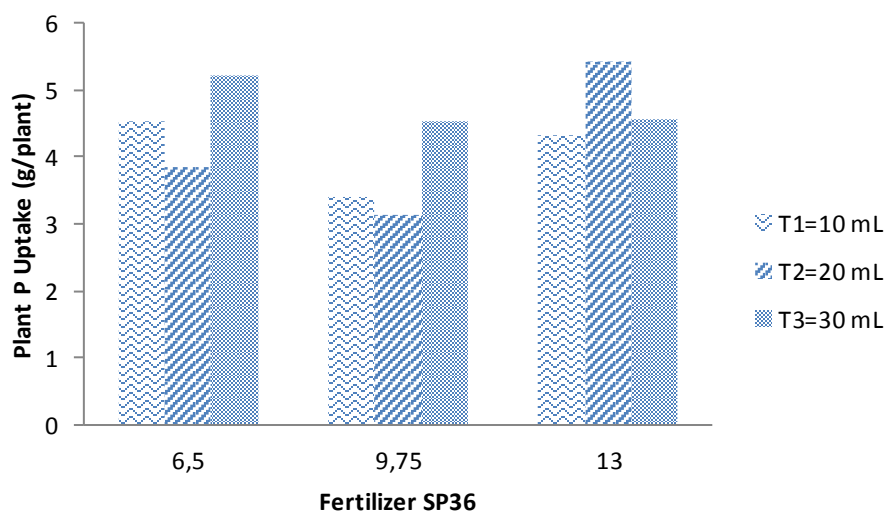


Figure 2: The relationship between *T.pinophilus* and SP36 Fertilizer on Plant P Uptake (mg/Plant)

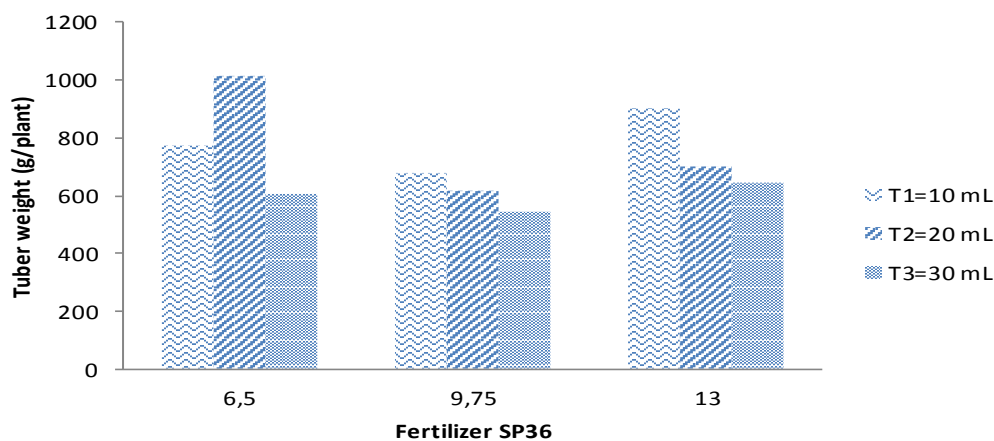


Figure 3: The relationship between *T.pinophilus* and SP36 Fertilizer on potato tuber yield (g)

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